ELECTROMAGNETIC METHODS FOR GEOTHERMAL EXPLORATION

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RESEARCH OBJECTIVES

The objective of the proposed research is to develop efficient numerical codes for mapping high-permeability zones, using single-hole electromagnetic (EM) data. These codes retain a reasonably high resolution, are simple to use, and do not require major computational resources. The work is in conjunction with the rapid development in instrumentation used for borehole EM surveys in producing geothermal fields. Mapping of fractures and other high-permeability zones are critically important because they play a very important role in developing and producing geothermal reservoirs.

APPROACH

A simple 2D inversion code for analyzing data obtained in single-borehole configurations was developed for laboratory use in FY00. The numerical method adopted is the integral equation, based on a modified Born approximation. The medium of interest is cylindrically symmetric in this case, and the resulting inversion algorithm will be simple enough to be implemented on PCs operated in the field. In FY01, the 2D inversion code development will be completed and field-tested for routine on-site use. In the next 3 years (FY02–FY04) the algorithm will be extended to investigate 3D electrical structures in the vicinity of boreholes. The medium will be divided azimuthally and radially to confirm cylindrical structure, but each element will be assigned different electrical conductivity.

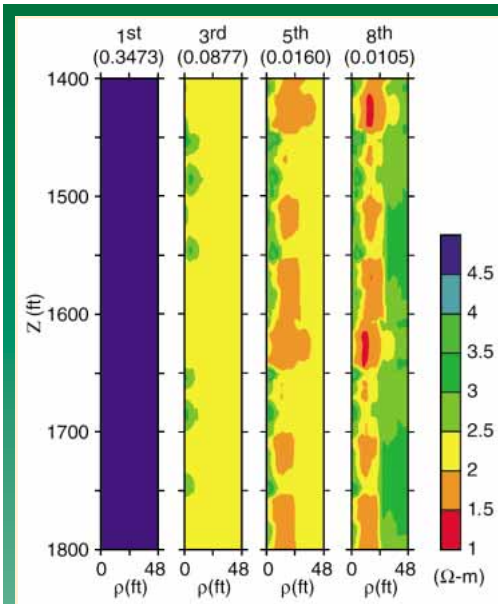

Figure 1. Conductivity imaging derived from the 2D inversion of data obtained from Chevron USA. The model started with uniform conductivity (far left) of 4 Ω-m, and after eight iterations, the misfit in terms of rms (shown as fractional numbers after the number of iterations shown at the top of each image) converged to about 1%.

ACCOMPLISHMENTS

In May 2000, Electromagnetic Instruments Inc. (EMI) conducted a field test of the newly built Geo-BILT tool (operated by Chevron USA) at Lost Hills oil field in southern California. Berkeley Lab evaluated the data for future development of the 3D approximate inversion scheme. As part of the final evaluation of 2D inversion code, we conducted a data inversion using only the Mz-Hz data. The result is shown in Figure 1.

SIGNIFICANCE OF FINDINGS

An important improvement has been implemented to the 2D inversion code developed for analyzing single-borehole EM data. The efficiency and robustness of an inversion scheme is very much dependent on the proper use of the Lagrange multiplier, which is often provided manually to achieve a desired convergence. We have developed an automatic Lagrange multiplier selection scheme. Successful application of the scheme will improve the ability of the code to handle field data.

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